Physics 344 Project 2B

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Seeing is Believing

Direct Measurement of the Wavefunction

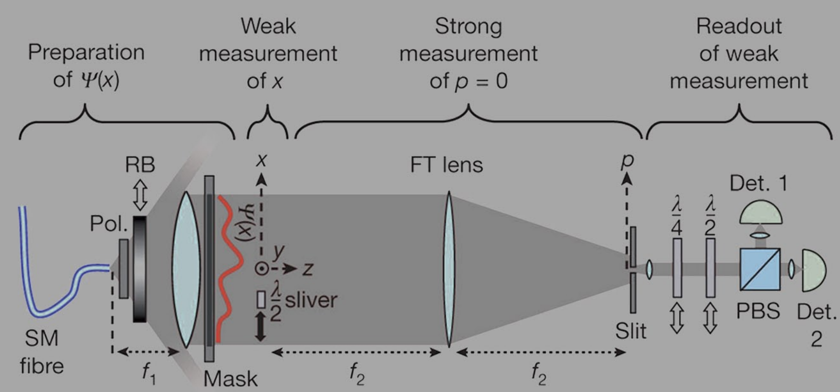
Central to quantum theory, the wavefunction is a complex distribution associated with a Artistic depiction of the wavefunction and apparatusquantum system. Despite its fundamental role, it is typically introduced as an abstract element of the theory with no explicit definition. Rather, physicists come to a working understanding of it through its use to calculate measurement outcome probabilities through the Born Rule. Tomographic methods can reconstruct the wavefunction from measured probabilities. In contrast, we demonstrated a method to directly measure the wavefunction so that its real and imaginary components appear straight on our measurement apparatus. At the heart of the method is a joint measurement of position and momentum that is made possible by weak measurement.

Procedures:

1. Produce a collection of photons possessing identical spatial wavefunctions by passing photons through an optical fiber.

2. Weakly measure the transverse position by inducing a small polarization rotation at a particular position, x.

3. Strongly measure the transverse momentum by using a Fourier Transform lens and selecting only those photons with momentum p=0.



4. Measure the average polarization rotation of these selected photons. This is proportional to the real part of the wavefunction at x.

5. Measure the average rotation of the polarization in the circular basis. (i.e. difference in the number of photons that have left-hand circular polarization and right-hand circular polarization). This is proportional to the imaginary part of the wavefunction at x.

6. Repeat for all x to scan through the wavefunction.

Significance:

This new measurement gives the wavefunction a plain and general meaning in terms of a specific set of operations. As well as boosting our understanding of the fundamentals of quantum mechanics, the technique could prove useful in cases where tomography cannot be used.